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ABSTRACT

The unified science program at Monona Grove High School, Monona, Wisconsin, is a four-year, concept-centered program based on the premise that all science is concerned with the nature of Matter and Energy and with matter-energy interactions as a function of Time. The consequence of these interactions is Change and it is this "Process of Change" which is the central theme of the program. This unified program is now in the third year in which all science taught at this school is part of the program. The evidence available at this point, both subjective and objective, indicates that a totally unified approach to science education at the secondary school level is practical and that this approach represents a more effective means of realizing the educational objectives established for the science program, at this high school, than was being achieved by the same staff working through a subject-oriented program. This report includes sections on the philosophy of science education, evolution of the program, criteria for structuring and characteristics of the program, subject content summary, program evaluation, facility development, and conclusions and recommendations. For description of student manuals, see SE 012 308; SE 012 309; and SE 012 149 to SE 012 152. (Author/PR)

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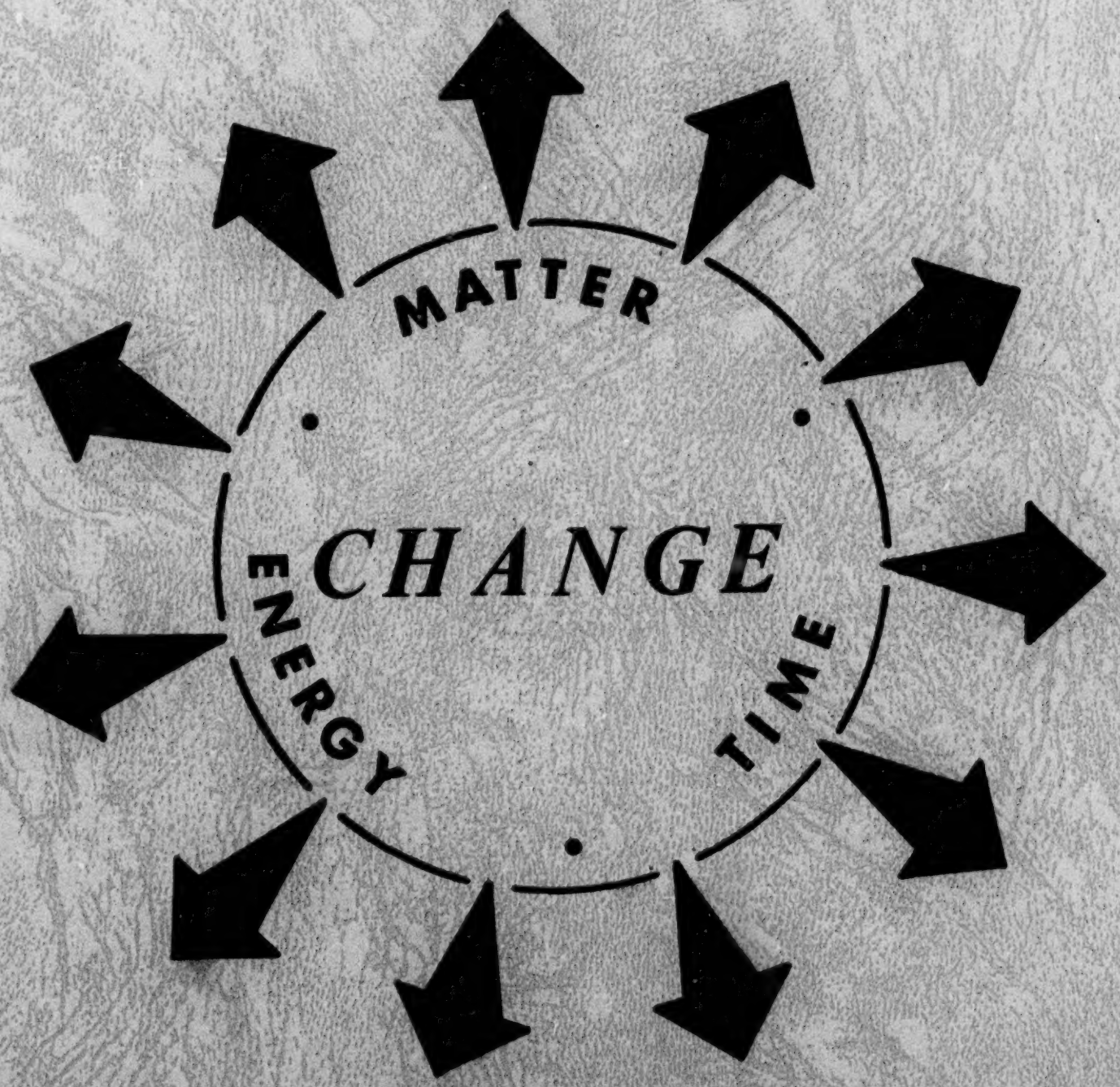

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Monona Grove High School
Monona, Wisconsin 53716

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FINAL REPORT

Cooperative Research Project No. H-271

Contract No. OE-6-10-161

THE DEVELOPMENT AND IMPLEMENTATION OF A FOUR-YEAR UNIFIED, CONCEPT-CENTERED SCIENCE CURRICULUM FOR SECONDARY SCHOOLS

Carl H. Pfeiffer
Monona Grove High School
4400 Monona Drive
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SUMMARY

The unified science program being implemented at Monona Grove High School, Monona, Wisconsin, is a four-year, concept-centered program based on the premise that all science is concerned with the nature of Matter and Energy and with matter-energy interactions as a function of Time. The consequence of these interactions is Change and it is this "Process of Change" which is the central theme of the program.

This unified program is now in its sixth year since being introduced at the freshman level in 1964 and the third year in which all science taught at this school has been part of the program. The evidence available at this point, both subjective and objective, indicates that a totally unified approach to science education at the secondary school level is practical and that this approach represents a more effective means of realizing the educational objectives established for the science program at this high school than was being achieved by the same staff working through a subject-oriented program.

INTRODUCTION

Philosophy of Science Education
The Rationale for a Unified Approach to Science Education

Prior to the close of the 19th Century the process of scientific investigation and the methods of science teaching were closely allied to philosophy. Although the quest for knowledge was being pursued in separate and well established disciplines, the scope of knowledge in any given subject field was not so extensive that it prevented investigators and teachers from reflecting upon the interdisciplinary nature of science and its implications for society.

During the period from 1920 to 1940, however, spectacular advances were achieved in all fields of science and the body of factual knowledge associated with the various disciplines experienced great "vertical" growth. Individual scientists were becoming more interested in extending the frontiers of knowledge within relatively narrow areas of their particular disciplines and less interested in the philosophical aspects of science. The era of specialization had begun! Science teaching during this period reflected these trends. Science curricula were extended to accommodate the influx of new factual knowledge and science teaching became more fact centered and specialized within the confines of the traditional science disciplines.

By mid century, specialization in science had come of age, and with it, numerous problems.

1) The frontiers of science had expanded so rapidly that communication between scientists became a serious problem.
2) Knowledge was being accumulated faster than it could be assimilated within the scientific community.
3) Research activity had become so complex and sophisticated that it became necessary to employ teams of specialists, often representing several different disciplines, to work cooperatively on common problems.

The interesting paradox in this dilemma is that the problems created as a result of individual specialization within the separate disciplines of science forced the disciplines within science to become more interdependent and interrelated. Within the vast spectrum of factual knowledge one finds threads of continuity which tie together areas of common concern and interest. Thus this unity, which permeates all science, provides the frame of reference which makes it possible to interpret new knowledge in terms of broad concepts already established. It is this unity within science that has made cooperative inquiry possible.

The growth and change which have characterized science since 1950 have created similar problems in science education. During the past ten years there has been a major effort to cope with these problems through curriculum reform. For the most part curriculum specialists have concentrated on the development of new programs designed to emphasize contemporary ideas and factual knowledge. With few exceptions these new programs have been strictly subject oriented and highly fact centered.

Although these programs have played a major role in updating science content in secondary school programs they have failed to interpret science in terms of the needs of young people.

In critically analyzing the curricular changes which have come about in the past decade one must return to the philosophy of science education. What is the purpose of science education at the secondary school level? Whose needs are to be served - those of young people whose desperate need is to understand the very nature of science and its implications for their lives - or the need of science to transmit its cultural and academic heritage? The answer is both. Both needs must be served. However, innovations in curricula during the past ten years have reflected a greater concern for meeting the needs of science than the needs of young people. Although more factual science is being taught today than at any period of history, young people are learning less about the nature of science. Science teachers, particularly at the secondary school level, must find ways of helping young people understand science in its broad perspective. They must identify and develop concepts which make science functional at the personal level and use contemporary factual knowledge as a means to this end. In the final analysis the rationale for any unified approach to science teaching is that it offers the greatest potential for realizing the goals of science education within the program of general education.

The Role of Science in General Education

Science represents a significant portion of our academic heritage which must be made available to young people in some meaningful coherent pattern. The ultimate goal in this venture is more intelligent behavior. The things that students learn should be functional in the sense that they help the student to understand himself, his relationship to others, and to the environment in which he must live and work. The educational program must be designed to enable students to see and appreciate these relationships in broad perspective. It must provide experiences which prepare students to expect and to deal effectively with the wide range of individual and group problems which characterize contemporary life. It must provide experiences which enable students to discover their own special abilities, interests, and opportunities to make worthwhile contributions to society.

In order to accomplish these goals of general education, science courses must be presented in such a way that students clearly recognize that science represents more than "courses in biology, chemistry or physics", more than weather maps and dissections, "rotten egg gas", ripple tanks, formulas and equations, more than ESC and BSCS or PSSC, DNA, ATP, and numerous other mnemonic sequences devised to represent names difficult to pronounce and harder to remember. Science courses should be presented in such a way that students see science, not simply as a course dealing with factual knowledge discovered by scientists, but more important, as a process by which one may acquire knowledge in his own right. Science courses should be presented in such a way that students come to realize that traditional subject area disciplines categorize man's knowledge about nature, but not nature itself - that in spite of man's ability to formulate laws and theories which explain

natural phenomena he cannot circumvent natural process without suffering the consequences of his action.

In the final analysis, the science phase of the general educational program must provide the basis for understanding what science is and what it is not, and what science can do and what it cannot do for individuals and for society.

General Objectives of Science Education

In 1959 the science staff at Monona Grove High School identified the following general objectives of science education to serve as guidelines for the evaluation and development of its own program and for the evaluation of science curricula being developed elsewhere.

1. TO STIMULATE CREATIVE AND IMAGINATIVE THOUGHT AND TO PROVIDE OPPORTUNITIES FOR ITS EXPRESSION

This objective appears so consistently in statements of educational philosophy that non-educators, perhaps even teachers, assume that the realization of this objective is more or less guaranteed in every classroom, with every student. The degree to which one succeeds in accomplishing this objective depends, to a large measure, upon the opportunities students have the direct participation in class sessions. Teachers must develop the art of asking discerning questions and discipline themselves to elicit student response. They must guard against maintaining a superior "mind set", so rigid, that the very basis for dialogue between student and teacher is discouraged.

2. TO DEVELOP AN AWARENESS OF THE PROBLEMS AND RESPONSIBILITIES FORCED UPON SOCIETY AS A RESULT OF MAN'S ACTIVITY WITHIN HIS ENVIRONMENT

Science courses must not be presented as academic areas isolated from the social, political and economic problems of society. The social implications associated with science teaching constitute a major concern for its inclusion in the general educational program of public high schools. It is important that all students, especially those who terminate their formal learning experience at the secondary school level, develop an awareness of the need for an involvement of science in many of the most difficult and critical problems that exist in the world today. Although the majority of our students will not become technically involved with the solutions to such problems, as citizens, they most certainly must be informed to the point where they can deal with them intelligently at the personal level.

3. TO DEVELOP INTEREST IN AND APPRECIATION FOR THE HUMANISTIC ASPECT OF SCIENCE

The ability of students to appreciate and interpret science at the personal level is markedly affected by the knowledge and interest gained through extensive reading of science literature. It was Thomas Carlyle who said "reading maketh the man". Browsing and reading for personal interest constitutes a dimension of learning which cannot be provided in the classroom. The reading habit, if developed, provides the basis for staying close to the ever expanding frontiers of knowledge. Readings from the history of science and of contemporary work, coupled with personal experience, help the student realize that the

process of science is a human enterprise dependent upon the curiosity, intuition, ingenuity, experiment, failure and perseverance of individuals.

4. TO DEVELOP ATTITUDES AND SKILLS ESSENTIAL IN USING THE PROCESS OF SCIENCE AS A MEANS OF GAINING KNOWLEDGE

Science, as a process, involves the technique of using one's existing knowledge creatively to learn something new. As such, it represents a unique and personal pathway to understanding. The science program must provide opportunities for students to develop investigative skills. Students must learn how to define problems clearly, to distinguish between what is known and what needs to be known. They need to learn how to formulate hypotheses which provide a basis for inquiry. They need experience in making judgments of what is reasonable and unreasonable. Priority must be given to the development of these kinds of attitudes and skills which make the learner resourceful as well as knowledgeable.

5. TO PROVIDE OPPORTUNITIES FOR GROWTH IN THE UNDERSTANDING OF THE MAJOR CONCEPTS IN SCIENCE

In order to develop understanding and subsequently accomplish the goal of "more intelligent behavior" it is necessary to deal with facts. However science teaching must not be regarded as a process of transferring an inventory of factual knowledge to students. The science curriculum should be "concept centered", not "fact centered". It must be organized around, and emphasize, the broad generalizations within science which provide the basis for understanding contemporary factual knowledge.

This is our "point of view" with reference to the aims and objectives of science education at the secondary level. Our purpose is to develop an attitude toward science - an appreciation of what science is, the effects that it has on our way of life, the problems that it has created, and the opportunities that it presents. We seek to provide experience which will help students identify with the world in which they live in order that the experience of life itself might become more purposeful and personally satisfying.

Evolvement of the Unified Program

The unified science program now under continuing development at Monona Grove High School evolved as a result of a gradual realization on the part of the science teachers that a unified approach to curriculum development offered the greatest potential for implementing their philosophy of science education.

The period of evolvement began in 1959 at a time when the science staff was attempting to resolve a number of problems associated with the influx of new subject matter into the curriculum. An analysis of the existing courses of study indicated that there was a significant amount of duplication of subject matter within the various courses. Questions were raised with respect to the need and justification for this duplication and with respect to the lack of communication within the department in planning for a meaningful, sequential, development of ideas. Further investigation revealed that in most instances the duplication was not relevant to the total program. Teachers were working

independently and without concern for the interrelationship of ideas that obviously existed. Teachers within the various disciplines assumed responsibility for developing "anew" the skills and concepts related to the factual content of their courses.

Although each of the separate courses within the science curriculum were organized in a most logical way, the structure and continuity of the science program was most illogical from the standpoint of students moving from one course into another. It became painfully apparent that our entire science program was inefficiently organized and becoming more concerned with the teaching of contemporary factual knowledge than with the task of interpreting science in terms of the needs of young people. Our curriculum development and program implementation had evolved to the point where one had difficulty justifying it in terms of the goals set down in our philosophy of science education.

It was at this time that the possibility of a unified approach to science education was first considered. The idea was eventually rejected as being impractical in terms of the numerous problems anticipated in the development and implementation of such a program.

The problems of developing a satisfactory science program persisted. Three years of experience with the BSCS program provided convincing evidence that the entire curriculum needed to reflect the interdisciplinary nature of science.

In 1961 a survey of existing unified science programs was made and again the advantages and problems of this approach were discussed. Although no action was taken there was a growing awareness that a unified approach to curriculum development merited serious consideration.

In the fall of 1962, after three years of backing away, the staff decided to move in the direction of a unified program. It was apparent from the outset that a wide variety of programs, each with unique advantages, was possible. For this reason considerable time was spent in an effort to structure a program consistent with our goals and objectives in science education.

METHODS

Criteria for Structuring the Unified Program

Six criteria were established to provide guidelines for the development and eventual implementation of the unified program at Monona Grove High School.

1) The program was to be concept centered - organized around fundamental ideas significant in all discipline of science.
2) The unified program would not be introduced on a trial basis with a select group of students. All traditional courses would be phased out of the curriculum and all students at all grade levels would become involved in the unified program.
3) Beginning at the freshman level, the unified program would be developed and phased into the existing curriculum sequentially over a four year period.
4) The first three years of the program would have a bi-level structure in order to provide a basis for working with students at different interest and ability levels.
5) Curriculum materials for student use would have to be prepared by the staff working cooperatively. For this reason it would be necessary that the entire staff and the administration commit themselves to the project for a minimum of four years, including summer sessions.
6) The entire program would be team developed and team taught with the various members of the staff assuming leadership in their particular areas of specialization.

During the academic year 1962-63 the staff, working first independently and then cooperatively, identified those science concepts which were considered to be essential to an understanding of science from the standpoint of secondary school students in a program of general education. As one might expect, the list of concepts identified was fantastic. There were long and sometimes highly spirited discussions over the question, "What is a concept?" Although the staff never did develop a single definition which satisfactorily encompassed each teachers' point of view, it was generally agreed that concepts are "big ideas possessed by individuals" and that these ideas, once internalized (conceptualized), provide the basis for interpreting new experience.

A survey of those concepts identified by the staff clearly showed that there are certain ideas in science so basic to the understanding of natural phenomena that they are common to all science disciplines. These fundamental ideas which enable scientists to account for the nature of matter and matter-energy interactions also provide the basis for structuring a unified program of science education. In retrospect the selection of these concepts was probably the most difficult phase of the entire project. By the same token it was probably the most critical, for it was through this process of identifying basic concepts of science that the staff began to understand their task as teachers of science. It was also through this experience that the teachers began to develop the mutual concern and respect needed to function effectively as a team.

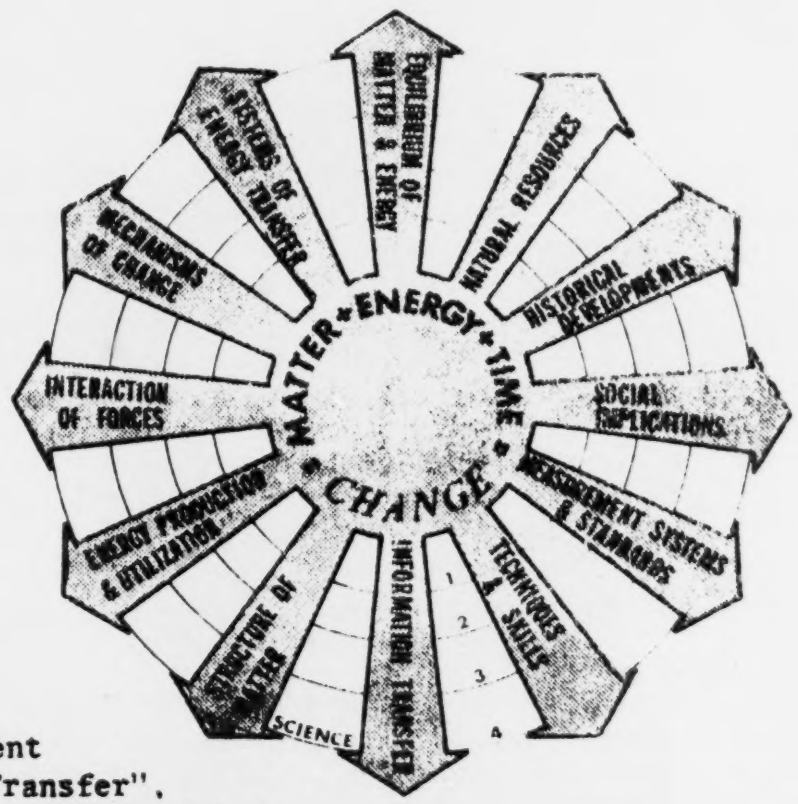
During the fall of 1963 the organizational structure for curriculum development was completed. The entire four year program was based on

the premise that all science is concerned with the nature of Matter and Energy and with interactions between matter and energy as a function of Time. The consequence of these interactions is Change and it is this "Process of Change" which was adopted as the central theme for the entire program.

The twelve unifying themes shown in the diagram were selected to amplify this central idea and to serve as guidelines in the development of specific courses within the curriculum.

There are many interdisciplinary concepts in science which could be used as unifying themes in curriculum development. Organizational themes helpful in structuring a unified curriculum have two characteristics in common. (1) They represent "big ideas" of interest in several scientific disciplines. (2) The ideas themselves are independent of time. "Systems of Energy Transfer", for example, possesses these characteristics. Although our understanding of a particular energy transport system is likely to change, energy transfers will continue to occur and continue to be of interest to those who seek understanding of natural phenomena.

Unifying Themes



The "big ideas" in science associated with the twelve unifying themes selected for the Monona Grove program would probably be incorporated into any unified science curriculum. Unifying themes are of value only to the extent that they provide an organizational framework for the fusing of ideas within the program. The uniqueness of the unified approach to science education, and perhaps its greatest strength, is that there is no prescribed basis for organizing these "big ideas" into a curriculum nor any restrictions placed on the selection of subject matter used to provide the experiences which enable students to internalize these ideas. The ideas which enable students to understand the nature of nature must be incorporated into every unified program. How these ideas are organized and then developed as concepts is a matter of individual preference and need.

Characteristics of the Monona Grove Program

In structuring the unified program at Monona Grove it was decided that a minimum of two years would be required in order to develop those concepts of science considered to be significant in terms of the needs

of all students. For this reason all students at Monona Grove are required to complete two years of unified science. This requirement must be satisfied by the end of the junior year.

The first three years of the program have a bi-level structure. The "A" and "B" level programs in Science I and II deal with the same basic concepts but differ significantly in the way that these concepts are presented and developed. Generally, the "A" programs are more theoretical and develop ideas to greater depth. Approximately forty percent of the students in Science I are placed in the "B" level program. This percentage remains about the same in Science IIB.

The purpose of the bi-level organization is to provide for gross differences in student ability and interest. These characteristics are not always apparent in students, especially with freshmen. Interests change and errors in accessing ability do occur. Occasionally, and most frequently with freshmen, there is a need to transfer students from one level to another. In order that these transfers might be effected without the loss of continuity the IA and IB programs were organized with a parallel structure in terms of the concepts to be presented.

During the course of the freshman year, student-teacher relationships are established which provide the basis for more effective guidance in the selection of courses. Concern for the problem of students transferring between the "A" and "B" levels was not a major factor in the design of the Science II curriculum. Although the basic concepts developed in Science IIA and IIB are about the same, the organization of ideas and the curriculum materials developed for their implementation are very different. Transfers within the Science II program are possible but the transition is not as smooth as it would be in the Science I program.

Science III and IV, the third and fourth year programs, are elective. The "A" and "B" level programs for Science III are very different. The "A" program employs a more quantitative and theoretical approach to concept development while the "B" program attempts to develop concepts in terms of contemporary, science related problems. As yet there are no plans for developing a IVB program.

By the spring of 1964 a preliminary outline for a four year, concept centered program had been completed. This program together with a proposed plan for implementation was approved by the local school administration. Curriculum materials for the first year of the unified program were prepared that summer and introduced at the freshman level during the 1964-65 school year. The Science II, III and IV programs were developed and phased into the curriculum, sequentially during the next three years. By the fall of 1967 the cycle was completed and all science students at the school were involved in the unified program.

FINDINGS AND ANALYSIS

Content (Subject Matter) Summary

The central theme selected to provide the guidelines for the organization of the four-year unified program at Monona Grove High School proposes that science is concerned with the nature of matter and energy and with matter-energy interactions as a function of time. The consequence of these interactions is change.

The purpose of science education is to develop an understanding of the nature of matter and energy and the process of change, to the end that the individual will better understand himself, his relationship to others, and to the environment in which he must live and work.

At the present time the following unifying themes provide the basis for structuring the four-year curriculum.

Year & Course Number	Major Theme	Approximate Distribution of Concepts Traditionally Associated with: Physical Science	Life Science
Science IA, IB	Matter-Energy and the Process of Change	80%	20%
Science IIA, IIB	Matter-Energy Interactions Relating to Life on Earth	20%	80%
Science IIIA	Matter-Energy Interactions in Natural Systems	90%	10%
IIIB	The Interaction of Man with His Environment	50%	50%
Science IV	Homeostatic Systems - Mechanisms For Survival	20%	80%

The first year of the unified program focuses mainly on the development of ideas associated with the structure and properties of matter, the nature of energy, and matter-energy interactions resulting in physical and chemical change. These ideas, first developed in relatively simple non-living systems, then provide the basis for dealing with the more complex interactions characteristic of living things.

The unified program has been structured to present in the space of two years an overview of those concepts considered to be relevant to the realization of the goals of science education. The third and fourth years in the program provide opportunities for students to extend these fundamental concepts.

The present organization of the unified program at Monona Grove is described in the following course outlines.

SCIENCE IA AND IB

MATTER-ENERGY AND THE PROCESS OF CHANGE

I. THE UNIVERSE AND MAN (5 weeks)

A. Basic Questions About the Universe
B. The Earth, It's Position in the Universe
C. Man's Early Concepts of the Earth and the Universe
D. Man and Science in the Changing Universe

II. MAN'S ATTEMPTS TO UNDERSTAND AND RELATE TO THE PROCESS OF CHANGE (3 weeks)

A. Sensory Experience, Knowledge, and the Process of Science
B. The Need for Quantitative Descriptions
C. Understanding Through Graphic Representation

III. MAN'S IDEAS ABOUT THE STRUCTURE OF MATTER (14 weeks)

A. Hypothesis, Theories, and the Process of Science
B. Properties of Matter and Physical Quantities
C. Classification of Matter
D. Basic Structure of Matter: Atoms, Molecules, and Cells
E. Particle Motion, the Kinetic State of Matter

IV. THE ROLE OF ENERGY AND TIME IN THE PROCESS OF CHANGE (5 weeks)

A. Energy, the Agent for Change
B. Force, Work, and the Concept of Energy
C. Fundamental Energy Forms
D. Energy, Time and the Concept of Power
E. Energy Resources and Their Utilization
F. Order - Disorder and the Process of Change

V. INTERACTIONS RESULTING IN PHYSICAL CHANGE (4 weeks)

A. Forces in the Universe Which Act to Effect Change
B. Interactions Within Structures
C. Physical Changes Resulting From Interactions
D. Interactions Between Macrostructures

VI. INTERACTIONS RESULTING IN CHEMICAL CHANGE (6 weeks)

A. The Historical Development of Chemical Change
B. The Nature of Chemical Change
C. The Chemical Equation, An Expression of Chemical Change
D. Oxidation, a Fundamental Chemical Process

SCIENCE IIA

MATTER-ENERGY INTERACTIONS RELATING TO LIFE ON EARTH

I. ORIGINS OF LIFE (17 weeks)

A. Historical Aspects of the Origin of Life

1. The Development of Man's Ideas About the Origin of Life
2. The Period of Information Accumulation and Classification

B. Origins of the Universe and Solar System

1. Basic Questions About the Universe
2. Origin of the Solar System
3. The Nature of the Primitive Earth

C. Conditions on Earth Before Life Began

1. Geologic Formations of the Earth
2. The Chemistry of the Primitive Atmosphere
3. The Chemistry of the Primitive Sea

D. Evolution of Organic Compounds

1. Energy, Its Role in the Life Process
2. Carbon, the Key to Life
3. The Chemistry of Carbon and Carbon Compounds

E. Organic Compounds in the Ancient Seas

1. Accumulation of Complex Polymers
2. The Formation of Coacervates

II. THE EVOLUTION OF LIFE (3 weeks)

A. The Cell Theory

1. Historical Development of the Cell Theory
2. The Cell Theory Today

B. The Role of Enzymes in Living Systems

1. Inorganic Catalysts vs. Enzymes
2. Factors Affecting Enzyme Activity

C. Fermentation and Respiration

1. Fermentation
2. Aerobic Respiration

D. Photosynthesis

1. Nature of Photochemical Reactions

2. The Nature of Photosynthesis
3. The Leaf - A Photosynthetic Organ

III. THE CONTINUITY OF LIFE (16 weeks)

A. Multicellularity - Problems of Complexity

1. Transitational Patterns
2. Plants - Structural and Functional Patterns
3. Animals - Structural and Functional Patterns

B. Reproduction, Growth, and Development

1. Sexual Reproduction
2. Growth and Development
3. Analysis of Development

C. Genetic Continuity

1. Probability
2. Patterns of Heredity
3. The Chromosome Theory
4. Master Molecules - Blueprints for Life
5. The Ideas of Evolution

SCIENCE IIB

MATTER-ENERGY INTERACTIONS RELATING TO LIFE ON EARTH

I. ORIGINS OF LIFE (9 weeks)

A. Origin of the Universe and Solar System

1. The Universe, A Perspective Review
2. The "Beginnings"

B. The Evolving Earth

1. Contemporary Conditions in the Geosphere
2. Conditions Before the "Dawn" of Life

C. Man's Ideas About the Origin of Life

1. The Nature of Living Organisms
2. Historical Views About the Origins of Life
3. Contemporary Hypothesis
4. Evolution of Living Organisms

II. The Unity and Diversity of Life (22 weeks)

A. The Cell Theory

1. Historical Development of Cell Theory
2. Composition and Variety of Cells
3. Variety and Organization of Cells
4. Life Functions of Cells
5. Mechanisms of Cell Function

B. Reproduction and Development

1. Asexual vs. Sexual Reproduction
2. Reproduction in Placental Mammals
3. Frog Reproduction and Development

C. Diversity of Life

1. Classification
2. Microorganisms

III. CONTINUITY OF LIFE (5 weeks)

A. Genetic Continuity

1. Principles of Heredity
2. The Genetic Material
3. Genes in Human Populations
4. Applied Genetics
5. Probability Laws

B. Environmental Interaction

SCIENCE IIIA

MATTER-ENERGY INTERACTIONS IN NATURAL SYSTEMS

I. EXTENSIONS OF THE PARTICLE THEORIES

A. Interactions in Gases (6 weeks)

1. Particle Motion - A Review
2. Pressure, Temperature, Volume Relationships

B. Mole Concept (5 weeks)

1. The Development and Implications of the Avogadro Hypothesis
2. Significance of the Avogadro Hypothesis in Contemporary Science
3. Ideal Gas Law Equation

C. Mechanism of Chemical Reactions (8 weeks)

1. Refinements of our Atomic Model
2. Periodicity
3. Quantitative Descriptions of Reaction Mechanisms in Gases

4. Quantitative Descriptions of Reaction Mechanisms in Solution
5. Oxidation-Reduction Reactions

II. ENERGY-TIME RELATIONSHIPS IN MACROSYSTEMS

A. Analysis of Vector Quantities (2 weeks)

1. Characteristics of Vector Quantities
2. Trigonometric Resolution of Vector Quantities
3. Graphic Resolution of Vector Quantities

B. Interactions in Static Equilibrium Systems (4 weeks)

1. Equilibrium Systems with Forces Acting at One Point
2. Equilibrium Systems with Forces Acting at More Than One Point

C. Interactions in Dynamic Systems (3 weeks)

1. Dynamic Systems in Equilibrium
2. Dynamic Systems Not in Equilibrium

III. ENERGY-TIME RELATIONSHIPS IN PARTICULATE SYSTEMS

A. Energy Distribution (2 weeks)

1. Energy Changes in Reactions
2. Activation Energy
3. Reaction Pathways

B. Reaction Rates (1 week)

1. Factors Influencing Rate of Reaction
2. Law of Mass Action

C. Equilibrium in Particulate Systems (4 weeks)

1. Qualitative Aspects of Equilibrium
2. Quantitative Aspects of Equilibrium
3. Equilibrium in Aqueous Solution

SCIENCE IIIB

THE INTERACTION OF MAN WITH HIS ENVIRONMENT

I. STRUCTURE AND DYNAMICS OF THE BIOSPHERE (4 weeks)

A. The Nature and Scope of Ecological Science

1. The Scope of Ecology
2. Levels of Organization Within the Biosphere
3. The Ecosphere

4. Major Biomes and Their Subdivisions

B. The Ecosystem

1. The Concept of Ecosystem
2. Component Parts
3. Community Structure and Dynamics
4. Energy Distribution and Balance Within Ecosystems
5. Microcosm Approach to Ecological Analysis

C. Man in the Biosphere

II. POPULATION STRUCTURE AND DYNAMICS (5 weeks)

A. Structure and Organization

1. The Individual and Species Concept
2. The Population and Community

B. The Functioning of Populations

1. Population Growth and Size Factors
2. The Ideas of Malthus
3. Population Interactions
4. Periodism

C. Population Genetics

1. Genetic Equilibrium
2. Evolution in Genetic Equilibrium

D. Human Populations

1. Basic Ecology of Man
2. Demography, Past and Present

III. PROBLEMS OF COEXISTENCE (25 weeks)

A. Problems of Coexistence with the Physical Environment

1. The Development and Distribution of Energy for Power
2. Utilization of Natural Resources (Air, Water, Soils Minerals)

B. Problems of Coexistence with Other Organisms

1. Parasitism, Predation, Symbiosis, Commensalism
2. Health and Disease
3. Agriculture
4. Wildlife

C. Problems of Coexistence Within Society

1. International Problems Within the Entire

Human Population
2. Problems Within Societies
3. Problems Within the Family as a Social Unit
4. Problems Between Individuals

D. Science and the Evolving Society

1. Science and Philosophy
2. Science and Religion

SCIENCE IV

HOMEOSTATIC SYSTEMS - MECHANISMS FOR SURVIVAL

INTRODUCTION

A. Problems of Survival Inherent in Living Systems
B. Matter-Energy Interactions Relating to Living Systems
C. Life and the Laws of Thermodynamics
D. The Concept of Homeostasis

I. EXTENSIONS OF ENERGY-FORCE RELATIONSHIPS

A. Magnetic Forces
B. Electrostatic Forces
C. Electromagnetic Induction
D. Electromagnetic Radiation

II. MECHANISMS FOR THE INTERACTION OF MATTER AND ENERGY IN LIVING ORGANISMS

A. Mechanisms Associated with the Capture, Storage and Utilization of Matter and Energy

1. Photosynthesis
2. Fermentation and Respiration
3. Bioluminescence
4. Vision
5. Hearing

B. Mechanisms Associated with the Transport, Regulation and and Exchange of Matter and Energy Throughout the Internal Environment

1. Composition of Body Fluids
2. Functions of Body Fluids
3. Dynamics of Body Fluids

C. Mechanisms Associated with the Ability of Organisms to Act and React.

1. The Physical and Chemical Basis for Movement
2. The Control and Coordination of Movement

3. The Role of the Endocrine System
4. Physical and Chemical Aspects of Sense Reception

D. Mechanisms by Which Living Matter Propagates Itself Through Space and Time

1. Reproduction, Growth and Development of Living Matter at Cellular, Organellar, and Molecular Levels
2. The Changes Undergone by Living Matter in Time and its Distribution in Space
3. Interactions Between Organisms and Environment that Relate to Changes and Distribution in Time and Space

III. BEHAVIORAL PATTERNS OF LIVING ORGANISMS

A. Unpredictability vs. predictability: Basic Problems in Understanding the Nature and Roots of Behavior

B. The Influence of Environment Upon Behavior

C. The Basic Patterns and Biological Machinery of Behavior

1. The Levels of Behavior
2. The Diversity of Behavioral Patterns
3. Relationship of Behavioral Patterns to Types of Nervous Systems
4. The Structural Diversity of Nervous Systems
5. Functional Unity of Nervous Systems

D. Human Behavior: Selected Topics

Program Evaluation

The continued analysis of an educational program is a difficult but essential aspect of curriculum development. A thorough program of evaluation must be centered around two basic issues:

1. the degree to which the educational experience provided for students enables them to realize the objectives established within the philosophical framework of the curriculum, and
2. the extent to which these objectives are relevant in terms of the needs of maturing young people.

Obviously one cannot evaluate the second of these issues until there is some assurance that the first has been accomplished. The first issue is of immediate concern. This aspect of evaluation cannot be separated from the teaching process. Teachers have a professional responsibility to establish educational goals and to continuously evaluate the effectiveness with which these goals are being realized.

Once an educational program has evolved to the point where there is evidence to indicate that its objectives are being accomplished, the objectives themselves must be evaluated.

The science staff at Monona Grove is still in the process of evaluating the degree to which its education objectives are being realized. During the period from 1959-63 it became increasingly apparent that a traditional subject oriented science program no longer provided the most desirable organization for accomplishing the educational objectives of the science program, that is:

1. to stimulate creative and imaginative thought and to provide opportunities for its expression.
2. to develop an awareness of the problems and responsibilities forced upon society as a result of man's activity within his environment.
3. to develop interest in and appreciation for the humanistic aspect of science.
4. to develop attitudes and skills essential in using the "Process of Science" as a means of gaining knowledge.
5. to provide opportunities for growth in the understanding of the major concepts in science.

The Unified, Concept Centered Program was developed in the belief that this approach provided the basis for a more complete realization of these objectives. The purpose of this continuing evaluation is to determine whether there is any evidence to support this point of view.

Three of the educational objectives established (1-3) have to do with student attitudes and abilities which are not directly related to the mastery of the subject matter. At the present time there is virtually no reliable basis for a quantitative evaluation of the extent to which these objectives are being achieved.

The major concern in shifting to a unified program was the belief that this type of organization would provide more opportunities to focus attention directly upon the attainment of these important objectives.

Both traditional subject oriented science programs and unified programs provide many opportunities for creative and imaginative thought. The realization of this objective depends more upon pedagogical techniques than curriculum organization. The team approach used to develop and implement the unified science program allows teachers to work cooperatively in planning activities that do stimulate creative and imaginative thought. Specifically, three types of activity, purposefully designed, to encourage individuals to think creatively, have evolved in the process of developing this unified program.

(1) An evaluation procedure designed to give each student an opportunity to reveal the degree to which basic concepts, under consideration, have been internalized and also the opportunity to demonstrate the level of his ability to use what he knows to interpret and evaluate new experience. This type of evaluation procedure does much more than measure the students' ability to recall factual knowledge. It gives the student an opportunity to use his knowledge to interpret, evaluate, and express opinion.
A sample of this type of evaluative device is included in the appendix, page 1. Part I of the device is designed to reveal the level of the students' comprehension with respect to the basic concepts under consideration. Part II asks the student to apply these ideas in familiar situations, similar to those considered in various class discussions and activities. Part III challenges the student to relate to a totally unfamiliar situation. Students have expressed a strong preference for this type of evaluative procedure.

(2) Science teachers like to believe that their laboratory activities constitute high level learning experiences which successfully involve students in the process of critical inquiry. This does happen but generally it is not the case for the majority of the students involved in laboratory activities. In an attempt to involve a larger percentage of students in the process of inquiry the science team cooperatively developed the following format for structuring laboratory activities within the unified program: a pre-laboratory session in which the student must demonstrate his understanding of the purpose for a particular laboratory activity before he is permitted to "experiment" on his own; a post-laboratory session to give the student a chance to interpret and evaluate the laboratory experience himself and with others.

When practicable, students are involved in the formulation of laboratory procedures designed to provide the information needed to evaluate a particular phenomenon. When more than one approach is proposed students are given the opportunity to select the line of inquiry which, in their mind, seems most reasonable.

Finally, students are given the opportunity to explore areas of personal interest through individual projects.

(3) The third activity designed to provide opportunities for personal inquiry and creative thought centers around a science resource center. During the first year that the unified program was introduced it became apparent that some type of facility was needed

to give students an opportunity to become more personally involved. Something was needed to bridge the gap between the student as an individual with very personal needs, ambitions, problems and abilities and the goals which all students were expected to accomplish in the science program. It is the role of the teacher to bridge this gap but individualizing instruction is not a simple matter. In traditional programs the textbook used in a particular course helps to meet some of the personal needs of students. In the unified program the common textbook had been replaced by a wide variety of resource materials. Most students were not prepared to make the transition to this type of reference aid.

The resource center idea was conceived as a means toward personalizing the learning process. It began in 1964 as a sort of science library area set up in one of the classrooms. In 1965 an audio tape system was added. The resource center at that time (see appendix page 8) could accommodate twenty students at carrels designed for independent study plus a maximum of twelve students at tables arranged for cooperative work. The facility contained printed reference materials including hardbound and paperback books, seventeen periodicals covering most science areas, and an extensive file of reprinted articles. The audio system was composed of four tape playback units connected to remote stations at the study carrels. Each carrel position had a selector switch and start button which permitted a student to select one of four taped programs and to start the machine. The playback units used cartridged tapes which, once started, ran to completion and turned off automatically.

Experience in the use of these facilities provided the basis for developing the following philosophy with regard to the role of a resource center in the overall educational program.

The major purpose of the resource center as part of the instructional program, is to provide a facility which permits the development of a variety of programs, carefully designed, to personalize the learning experience of students. The realization of this objective is dependent upon many factors. However, two are of primary importance:

1. The resource center facility must be structured and operated in such a way as to provide an atmosphere which permits and encourages students to become personally involved in the learning process.
2. The resource center must provide a variety of programs which permit students to relate to the ideas being presented as a part of the curriculum in ways which are not possible in general class sessions.

The resource center must be developed as an integral part of the instructional program. It must not become an entity unto itself, unrelated to the day-to-day activites and concerns which go on within the classrooms of the academic area it serves. Neither must it become a facility which merely substitutes for the kind of activity which could just as well be conducted within the classroom, the library or a study hall. A resource center should provide a variety of program types specifically designed for different student needs.

"Individualized Study Programs" should be developed which provide materials, sufficient direction, and guidance to enable students to pursue a particular idea (concept) being developed by the class, at his own rate and to a depth which he determines to be relevant to his needs or interest.

"Independent Study Programs" should be developed which provide opportunities for highly motivated students to plan and if they desire, carry out investigations based on original ideas rather than those prescribed by the teacher or text books.

Some resource center programs should be especially designed to deal with concepts which are difficult for certain students to understand. They must be imaginative programs which recognize the problems of these students and deal with them in ways which would not be possible or appropriate in other learner-teacher situations.

Some types of programs should be designed for all students within a class simply because facilities within the resource center permit the presentation of an idea or skill in a manner far superior to any approach which could be used in a classroom situation. Manipulative techniques and skill development are particularly suited to this kind of learning experience.

All programs, regardless of the specific purpose for which they are designed should employ a multi-media approach. There are a number of possibilities. Perhaps the most exciting is the couple between sound and 8mm films. Good quality films, cartridged or reel type, are now available which relate to practically any concept or skill associated with science teaching at the secondary school level. When the need for a particular type of program to personalize instruction becomes apparent one can usually find an appropriate commercially prepared 8mm film.

The most effective use of these films is realized when the teacher couples this visual media, utilizing a stop action feature, to an audio system thus converting a 3 or 4 minute silent film into a 20 to 30 minute audio-visual program which is uniquely appropriate to the needs of a particular situation in a particular school.

Similarly, audio-visual programs can be developed using a series of 2 x 2 slides or 35mm film strips to provide the visual dimension. All programs must be carefully structured so as to involve the student on a personal basis. This "personal touch" must be built into each program. Throughout the production of a program the teacher must maintain a mental perspective of a one-to-one learner-teacher relationship. Although many students will use the program each should feel that the teacher is working directly with him.

Physical equipment and materials are essential in the development of a resource center facility. However, the center itself can be no more effective than the programs that creative teachers build into them. This takes time, a lot of time. It takes experience, a certain amount of technical skill, and of course, the financial support needed to carry on this type of program development.

The teacher's role in a one-to-one counselling or teaching situation with students who come to the resource center is extremely important. The students must know that "this is a place to come when help is needed."

Resource center programs within any given school must be designed with the total curriculum and the student in mind. They must have some common goals and operating procedures. In no case can a program of one department become so demanding, in terms of a student's time, that it jeopardizes the common goals of the general educational program.

Providing for resource centers within a school facility is no guarantee that the quality of teaching and learning within that school will be improved. However, the development of resource center programs as an integral part of a well defined and carefully planned instructional program offers a most exciting and realistic opportunity to personalize the teaching-learning process. When this happens the quality of education will be improved.

There is no quantitative evidence to prove that the development of these three types of activities has, in fact, increased the frequency with which students think creatively or that the teaching-learning process developed through the unified approach has more effectively bridged the "personality gap" between teachers and learners. However, it is a fact that through the implementation of this unified program the opportunities which stimulate this type of behavior have been greatly increased.

One might argue that any or all of these inovations could have been developed by teachers working within specific disciplines in a traditional science program. The point is that these same teachers, operating for eight years in that type of situation, did not. The team approach necessary to develop and implement a unified program enables teachers to work cooperatively in planning and directing activities which encourage students to become involved as thinking individuals.

The social implications of science have always been stressed when justifying the role of science in general education. However, this important educational objective became relatively insignificant in practice, amid the factual content associated with subject oriented curricula. The unified science program at Monona Grove is based on the premise that the social implications of science constitute one of the major themes which provide the frame of reference for the selection and ordering of concepts to be included in the program. Although this theme is apparent in many of the materials developed for use in the unified program, as yet, it does not have the impact on the total program that is needed.

One of the major problems associated with the subject oriented science curriculum was that it failed to provide a logical basis for enabling students to make the transition between the academic and functional nature of science. Science, at the secondary school level, needs to be functional. It becomes functional when it helps individuals interpret and evaluate new experiences. The subject oriented program emphasized the academic nature of separate disciplines within science but

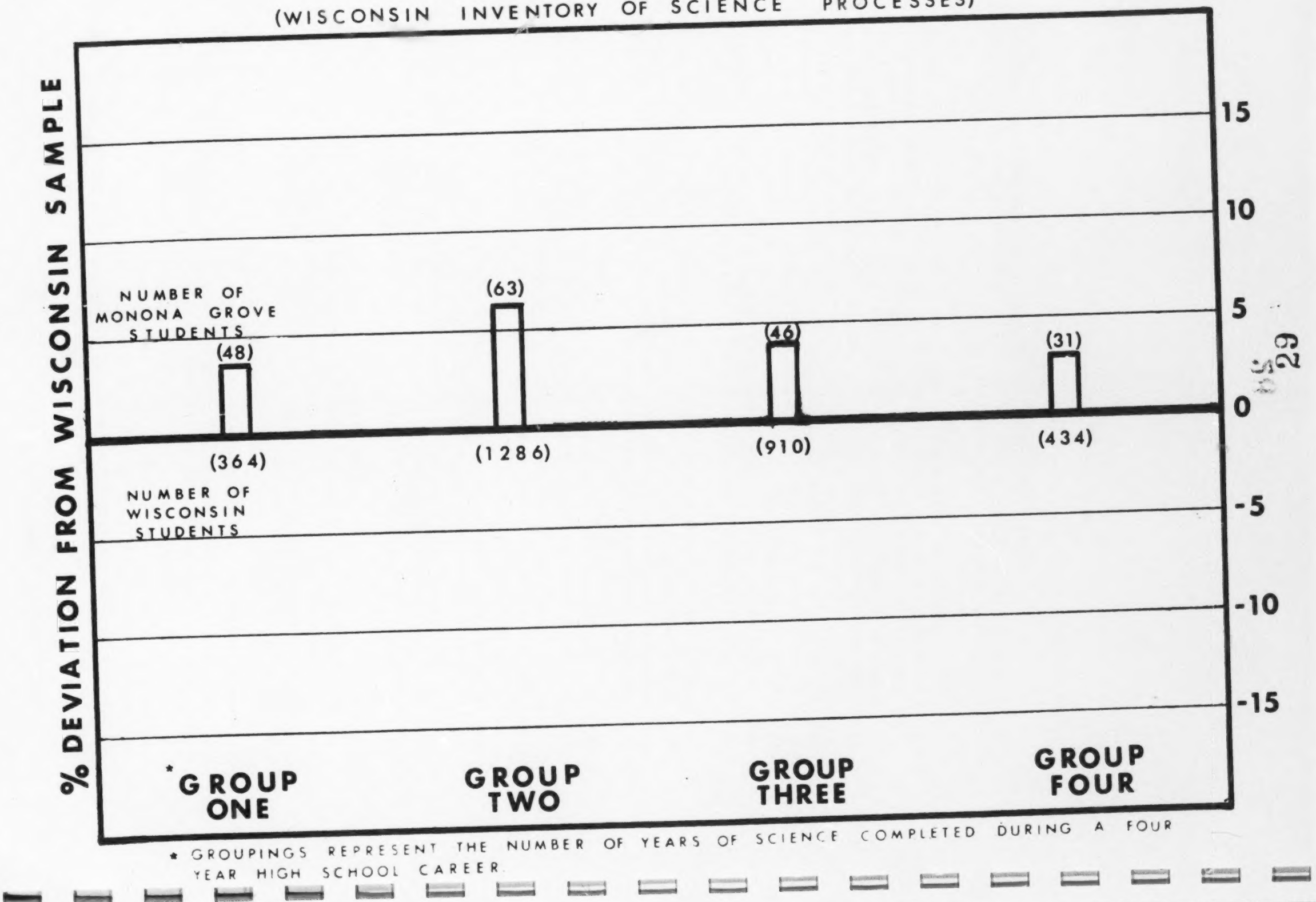
lacked the continuity needed to clearly establish the big ideas needed to make the process of science a personal experience.

The unified program was designed to make the science experience of students more functional, to personalize the process of science. In the unified program there is a conscious effort to use contemporary factual science to develop fundamental ideas useful in interpreting new experience. The subject oriented program treated the academic nature of science as an end in itself.

The WISP test (Wisconsin Inventory of Science Processes) provides a limited basis for a quantitative measure of the degree to which this objective has been achieved with students participating in the unified program. The WISP test, Wisconsin Inventory of Science Processes, was developed by the Scientific Literacy Research Center, University of Wisconsin, Madison, Wisconsin and was published in 1967. This instrument, designed as an inventory of knowledge of the scientific enterprise, was used to measure students' understanding of processes of science. The test was administered to the Monona Grove Seniors, class of 1968. The performance of these students, whose entire experience in secondary school science was in the unified program, is shown as a percentage deviation from the average score of 2,944 students, with subject oriented science backgrounds, from other Wisconsin high schools. The percentile scores of the Monona Grove students are shown as a percentage deviation from the Wisconsin norms in four different groupings representing the number of years of science completed during the course of a four year high school career.

WISP TEST

(WISCONSIN INVENTORY OF SCIENCE PROCESSES)



* GROUPINGS REPRESENT THE NUMBER OF YEARS OF SCIENCE COMPLETED DURING A FOUR YEAR HIGH SCHOOL CAREER.

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In spite of the importance of these humanistic goals in science education there is a tendency to evaluate the success of a program mainly in terms of those objectives for which quantitative measures are readily available. Educational psychologists have developed a wide variety of objective tests designed to measure academic ability, interest, proficiency and acheivement. These instruments provide a quantitative basis for evaluating those educational goals which are associated with the academic success of students. Objectives (4) and (5) are concerned with this aspect of science education.

(4) To develop attitudes and skills essential in using the process of science as a means of gaining knowledge.
(5) To provide opportunities for growth in the understanding of the major concepts in science.

The initial evaluation of the extent to which these academic objectives have been realized in both the traditional and unified science programs at Monona Grove High School is to be based on the performance of students over an eight year period. This sample includes four graduating classes with traditional science experience, 1964 through 1967, and four classes with unified science background, 1968 through 1971. Science enrollments for the classes graduated during the period from 1964 through 1969 plus figures for the classes to be graduated 1970 through 1973, provide the basis for recognizing certain trends in the science enrollments at this high school during the period of one decade.

The percentage of students electing three and four years of science in the traditional program during the four year period from 1964-1967 decreased from 21% to 13% for students electing a third year and from 15% to 9% for those students completing four years of science.

In 1965 the number of years of science required of all students graduating from Monona Grove High School was changed from one to two years. This change may be responsible for the increase in the percentage of students going on to elect a third and fourth year of science in the unified program. However, in the class of 1968, the first to graduate in the unified science program, 23% elected to take a third year of science although the requirement for graduation at that time was still only one year. Also, the percentage of students electing a third year of science in the unified program under the two year requirement has increased from 37% in 1969 to the point where 41% of all junior students, class of 1971, have already elected a third year of science.

These trends would seem to indicate that students find the unified science program to be more relevant to their needs than the traditional science program that was offered at this high school.

SCIENCE ENROLLMENTS - TRADITIONAL

NUMBER OF YEARS SCIENCE COMPLETED	CLASS; 1964 NUMBER OF GRADUATES (291)		CLASS; 1965 NUMBER OF GRADUATES (215)		CLASS; 1966 NUMBER OF GRADUATES (193)		CLASS; 1967 NUMBER OF GRADUATES (199)	
	NUMBER OF STUDENTS	%	NUMBER OF STUDENTS	%	NUMBER OF STUDENTS	%	NUMBER OF STUDENTS	%
1	82	28	70	33	53	27	74	37
2	103	36	77	36	87	40	82	41
3	62	21	39	18	38	20	26	13
4	*44	15	29	13	25	13	17	9

*LAST YEAR FOR SOPH PHYSICAL SCIENCE COURSE

SCIENCE ENROLLMENTS – UNIFIED

NUMBER OF YEARS SCIENCE COMPLETED	CLASS; 1968 NUMBER OF GRADUATES (205)		CLASS; 1969 NUMBER OF GRADUATES (239)		NUMBER OF YEARS OF SCIENCE	CLASS; 1970 CLASS SIZE (as seniors) (235)		CLASS; 1971 CLASS SIZE (as juniors) (270)		CLASS; 1972 CLASS SIZE (as sophomores) (244)		CLASS; 1973 CLASS SIZE (as freshmen) (282)	
	NUMBER OF STUDENTS	%	NUMBER OF STUDENTS	%		NUMBER OF STUDENTS	%	NUMBER OF STUDENTS	%	NUMBER OF STUDENTS	%	NUMBER OF STUDENTS	%
1	55	27	0	0	1	0	0	0	0	22	9	*265	94
2	73	35	124	52	2	112	47	158	59	*222			
3	47	23	88	37	3	89	38	*112	41				
4	30	15	27	11	4	*34	15						

* BASED ON 1969–70 ENROLLMENTS AS OF JUNE 11, 1969

Objective Evaluation

The following instruments were used to obtain standardized test data for the purpose of analyzing the degree to which the academic objectives (4) and (5) were being accomplished in the traditional and unified programs:

1) Henman Nelson Test - native intelligence
2) Iowa Test - natural science
3) Iowa Test - quantitative
4) STEP Test - natural science
5) SCAT Test - quantitative
6) ACT - American College Testing Program (natural science)

The sample representing the traditional science program includes 898 students graduated over the four year period from 1964-67. The unified sample includes 444 graduates from the classes of 1968 and 1969. The students from both samples have been divided into groups numbered one through four. The group number indicates the number of years of science completed during the course of a four year high school career.

The students in each group were tested twice (ACT Test excepted). The first tests were administered in the fall of the freshman year (graduating classes of 1964-65-66) and in the spring of the year prior to entering high school, for all classes since 1966. For all students the second test followed the first by a period of two years.

Since all of the group samples involve classes of students differing in average native ability and because the testing program was carried out at different times over an eight year period, all achievement test results have been corollated with Henman Nelson ability averages.

All achievement test data presented are percentile rankings based on national norms. These data are then shown as a percentage deviation, + or -, from the average Henman Nelson percentile for the various groups. In the graphic presentation of results the unified groups are represented by clear bars. The traditional group deviations are shown as shaded bars.

The graph contrasting the performance of traditional and unified students on the STEP-IOWA natural science tests shows a negative deviation from the Henman Nelson percentile rank for all groups after two years. The degree of change in the deviation between the Henman Nelson and the achievement test rank for each particular group is of special interest. In each of the four groups, representing the number of years of science taken in high school, the percent of deviation below the Henman Nelson average has been less for those students involved in the unified program. The most significant difference is noted for the group completing two years of science during a four year high school career. The deviation from the Henman Nelson scores for these students in the traditional group dropped 14% whereas the average deviation for the students in the unified program had dropped 4% two years later.

The test data provided by the SCAT-IOWA (quantitative) tests for students involved in the traditional and unified programs does not show any clear-cut advantage for either program. For those students completing only one year of science the traditional group shows a negative deviation of 2% after two years. The unified group, for the same period had a positive deviation of 10%. On the other hand, the data for those students completing two years of science shows that both the traditional and unified groups experienced a negative deviation of about 4%. Those students on the traditional program completing three and four years of science showed a slight positive deviation while the unified groups in the same category showed no deviation from their Henman Nelson percentile rank after two years.

Test data from the American College Testing Program provides a limited basis for evaluating the academic achievement of the students as seniors.

Fifty-one percent of the students graduated from 1964 through 1967 (all traditional science) took the ACT. Seventy-five percent of the students graduated in 1968 and 1969 (unified science) participated in the American College Testing Program. The composite mean score, in natural science, for the 471 students in the traditional group is 22.5. The unified group, which includes 319 students achieved a composite mean of 22.8. The national mean for the ACT (natural science) for college bound seniors is *20.3. * Based on the scores of 2,415,460 college bound students who took the ACT examination between 1965 and 1968.

With the exception of group one, which includes only 21 individuals in the unified sample, the percentage deviation from the Henman Nelson percentile rank favors the unified program. Although the difference in the percent deviation between the traditional and unified samples is small it should be noted that the number of individuals in the unified sample represents a larger percentage of the school population. For example, in the traditional sample, group two, 195 individuals took the ACT during a four year period. The comparative group in the unified sample has 162 students in just two years.

TRADITIONAL SCIENCE
(COMBINED TEST DATA)
GRADUATING CLASSES OF 1964 – 65 – 66 – 67

NUMBER OF YEARS SCIENCE COMPLETED	GRADE 9 (FALL) PRE HIGH SCHOOL EXPERIENCE			GRADE 11 (FALL)			GRADE 12	
	HENMAN NELSON	IOWA NATURAL SCIENCE	IOWA QUANT–	HENMAN NELSON	IOWA NATURAL SCIENCE	IOWA QUANT–	HENMAN NELSON	ACT NATURAL SCIENCE
*1	214 / 54	184 / 55	120 / 55	246 / 56	250 / 48	251 / 55	46 / 71	48 / 38
2	251 / 70	217 / 70	146 / 69	318 / 77	302 / 63	303 / 73	186 / 81	195 / 54
3	120 / 86	106 / 82	85 / 83	165 / 83	160 / 74	163 / 83	133 / 85	134 / 65
4	86 / 90	72 / 91	58 / 88	111 / 89	109 / 87	111 / 90	92 / 88	94 / 78

NUMBER IN SAMPLE

UNIFIED SCIENCE
(COMBINED TEST DATA)
GRADUATING CLASSES OF 1968 – 69

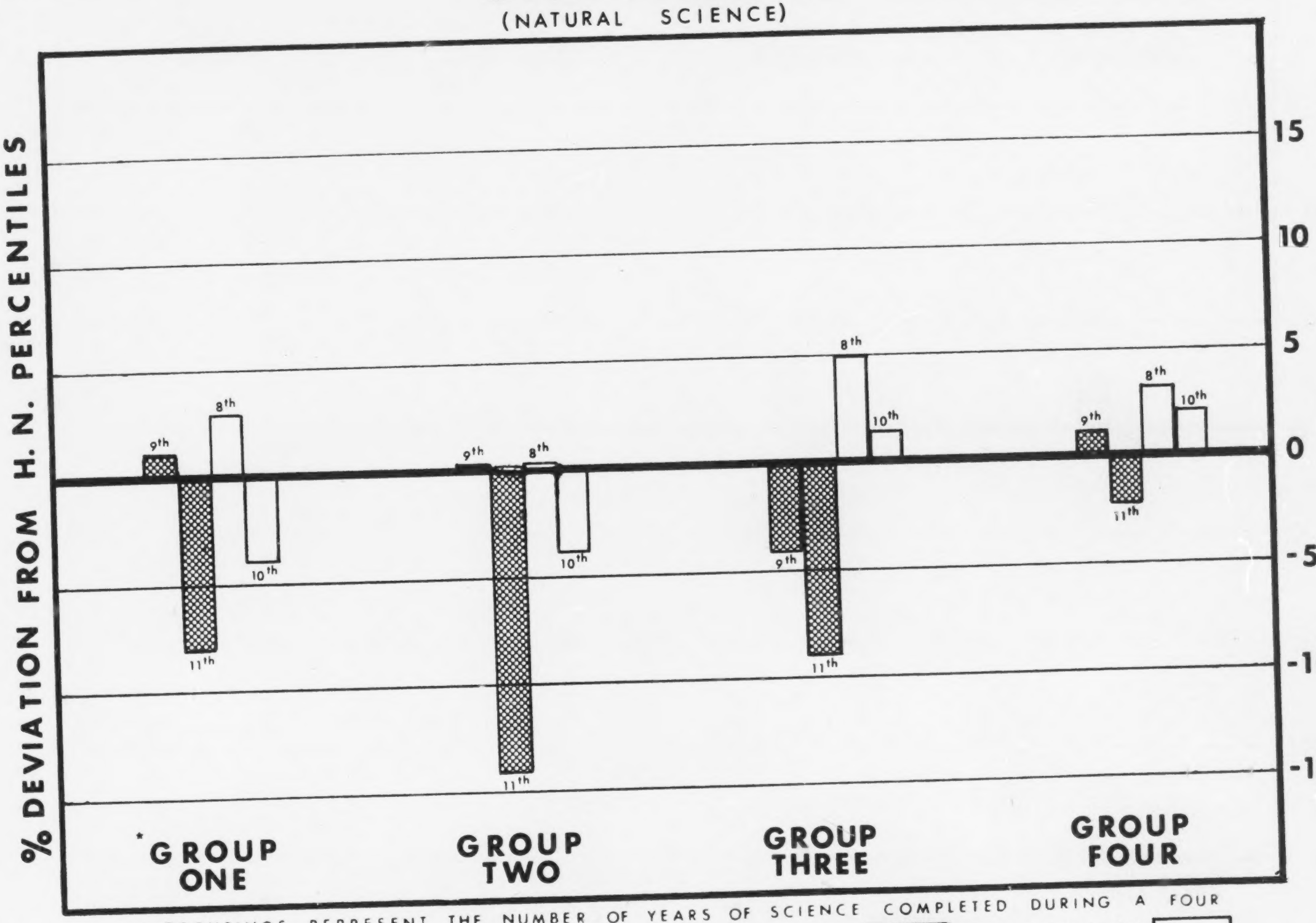
NUMBER OF YEARS SCIENCE COMPLETED	GRADE 8 (SPRING) PRE HIGH SCHOOL EXPERIENCE			GRADE 10 (SPRING)			GRADE 12	
	HENMAN NELSON	STEP NATURAL SCIENCE	SCAT QUANT–	HENMAN NELSON	STEP NATURAL SCIENCE	SCAT QUANT–	HENMAN NELSON	ACT NATURAL SCIENCE
*1	37 / 56	40 / 59	41 / 42	49 / 59	47 / 55	48 / 55	21 / 64	21 / 25
2	209 / 77	195 / 77	196 / 76	207 / 79	217 / 75	215 / 74	158 / 82	162 / 59
3	96 / 78	91 / 83	91 / 77	102 / 81	102 / 82	103 / 80	84 / 82	85 / 66
4	49 / 82	49 / 85	49 / 82	56 / 85	56 / 87	55 / 85	51 / 85	51 / 77

* NUMBERS REPRESENT THE YEARS OF SCIENCE COMPLETED AT THE CONCLUSION OF FOUR YEARS OF HIGH SCHOOL.

ALL TEST DATA SHOWN ARE BASED ON NATIONAL PERCENTILE RANKS. ACT SCORES SHOWN ARE NATIONAL PERCENTILE RANKS FOR COLLEGE BOUND HIGH SCHOOL SENIORS.

STEP – IOWA

(NATURAL SCIENCE)

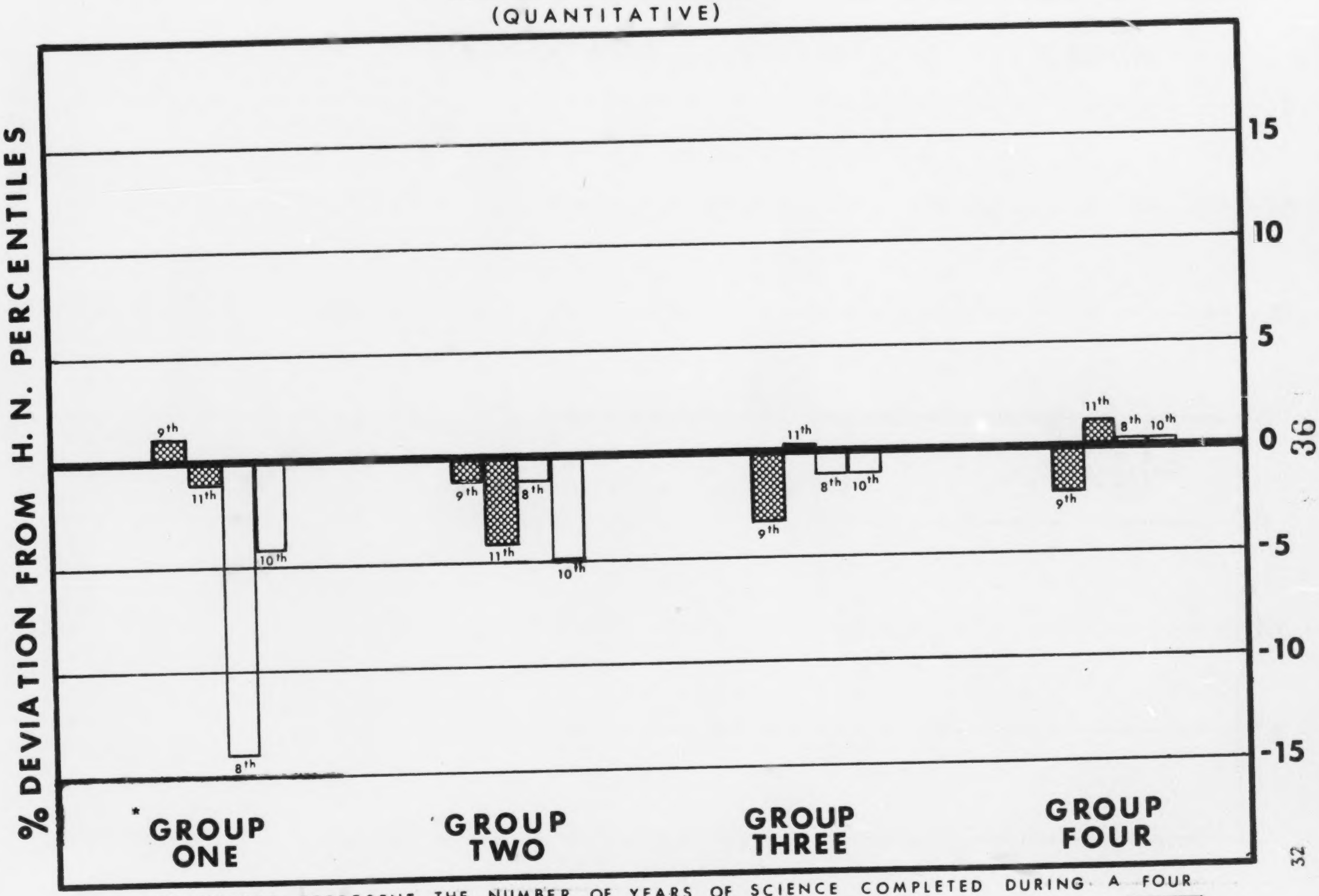


* GROUPINGS REPRESENT THE NUMBER OF YEARS OF SCIENCE COMPLETED DURING A FOUR YEAR HIGH SCHOOL CAREER.

TRADITIONAL ▨ UNIFIED □

SCAT-IOWA

(QUANTITATIVE)

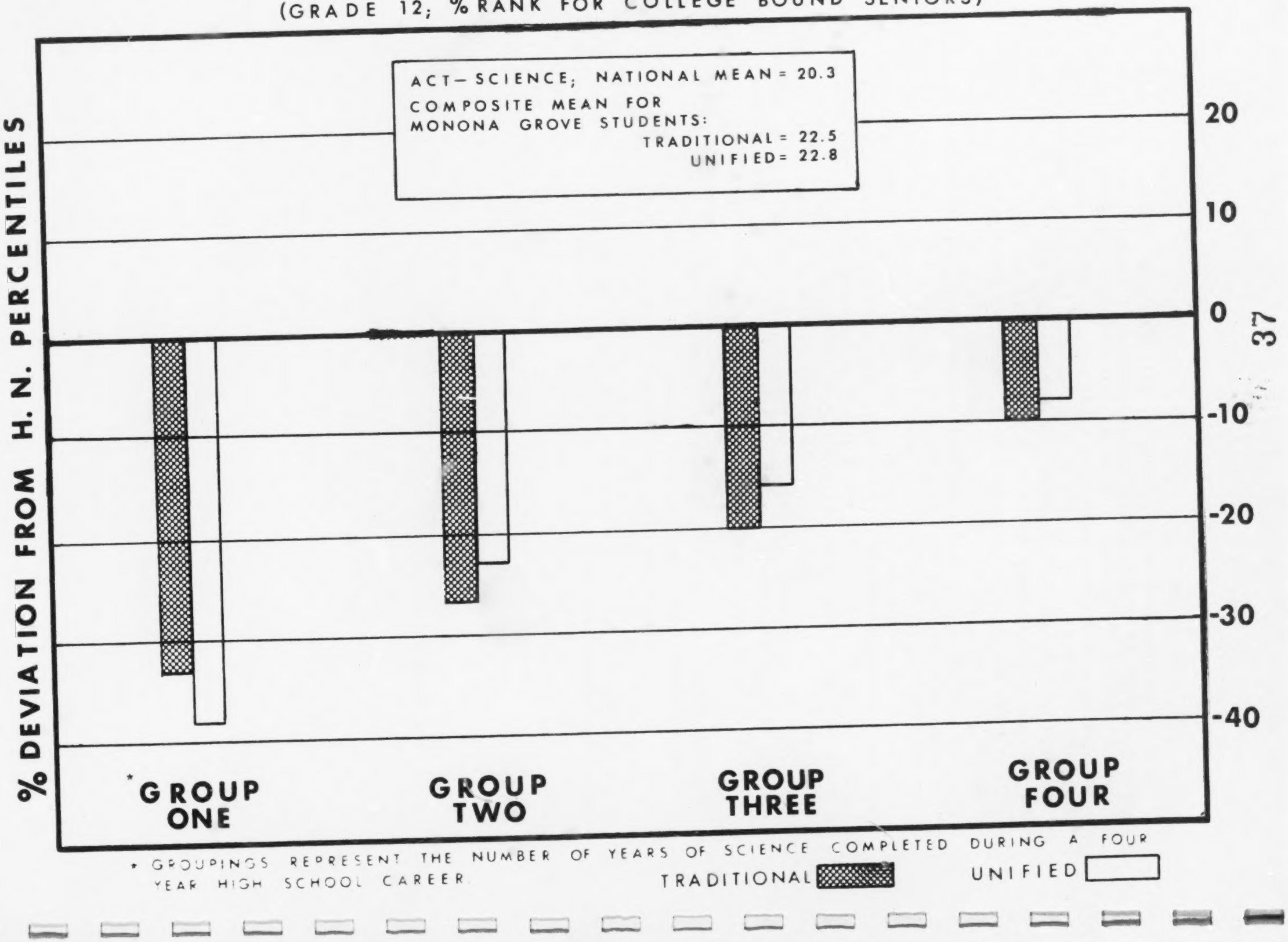


* GROUPINGS REPRESENT THE NUMBER OF YEARS OF SCIENCE COMPLETED DURING A FOUR YEAR HIGH SCHOOL CAREER.

TRADITIONAL ▨ UNIFIED □

ACT - SCIENCE

(GRADE 12; % RANK FOR COLLEGE BOUND SENIORS)



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Facility Development

During the first five years of its existence the unified program at Monona Grove was carried on utilizing facilities designed for a traditional subject oriented program. (Page 8 in the appendix) illustrates how these facilities were modified to accommodate the unified program.

The large group area necessary to make team teaching practical was provided by replacing the free standing laboratory tables from one classroom with tablet arm chairs. This modification provided seating for a maximum of 60 students. The tables were moved into an unusually long laboratory room to provide a second area with twice the seating capacity of a normal classroom. Doubling class size for large group instruction made it possible to free one classroom which was then modified for use as a resource center area. The study carrels in this area were fabricated by bolting dividers between the laboratory tables already present in the room. Large group instruction also provided a means of gaining additional teacher time for working with students in small groups.

Perhaps the most tangible indication of the impact that the unified program has had on this school is to be found in the changes that have come about in its physical facilities. In 1968 a remodeling and building program in excess of nine hundred thousand dollars was initiated in order to provide facilities better suited to the implementation of the educational program being evolved, not only in science but in other areas of the school as well. Page 9 in the appendix shows the expanded facilities now being completed in the science area.

The advantage of the increased size of the large group area is that it provides more opportunities for teachers to work with students in small groupings and on an individual basis.

The resource center area has been greatly expanded, not only in area but more important, in terms of the equipment available to facilitate the development of the resource center philosophy.

The procedure of making one particular audio program available to a number of students simultaneously via electronic channeling has been abandoned. Experience in the preparation and use of programmed materials designed to meet the special needs of students has shown that maximum benefits from the use of these materials cannot be realized unless each individual is able to control the rate at which the material is used. This type of flexibility has been provided through the use of individual cassette recorders and program tapes at each carrel position. Multiple copies of audio programs are quickly and efficiently reproduced from the master tapes by means of cassette duplicating equipment.

Whether team teaching, including those approaches which utilize large and small group instruction, is or is not to be a part of the plan for implementing a unified program it is possible to adapt existing physical facilities to provide for the space requirements of a unified program. However, if large group teaching is to be a continuing aspect of the instructional program a facility especially designed and equipped to maximize learning opportunities in this teaching mode should be provided.

CONCLUSIONS AND RECOMMENDATIONS

The unified science program at Monona Grove is now in the sixth year since its introduction at the freshman level in September, 1964. Since the fall of 1967 all science taught at this high school has been part of the unified program.

The evidence available at this point, both subjective and objective, indicates that a totally unified approach to science education at the secondary school level is practical and that it represents a more effective means of realizing the educational objectives established for the science program at this high school than was being achieved through a subject oriented program.

The evaluation of the unified program in terms of the educational goals established for this school system must be continued in the years ahead. The organization of ideas and the curriculum materials being used in the various programs are not fixed. At the present time many of the ideas associated with various portions of the program, especially IIA, IIB, IVA and IIIB are still not "naturally" fused into the conceptual framework specified for the program. The continued experience of the team, working with these ideas and with students, may provide the insight and wisdom required to more fully realize the goals of the program. Phase two of the evaluative process, a program to determine the validity of the stated educational objectives, in terms of their relevance to the needs of maturing young people, is totally before us.

The greatest strength of a unified science curriculum is that it provides a structure for presenting the "big ideas" of science in such a way that students come to the point where they are capable of thinking in terms of broad generalizations about the nature of science. This kind of insight, relative to natural phenomena, is what makes the science experience of the student relevant. It helps the student to realize that science is a process which involves individuals personally, a process by which one comes to understand "the nature of nature" and through this to understand himself. Subject oriented science curricula that fail to establish the interrelationship of ideas which exist within and between the various courses leaves to the student the difficult task of conceptualizing the ideas which make science relevant. The result is that the vast majority of students who study science in this context never really understand the implications of science for life.

The most significant single effect that the unified program has had on the educational program here has been the evolvement of the resource center concept as an integral part of the educational process. It is this type of experience which, perhaps for the first time in the history of mass public education, provides genuine opportunities for personalizing (individualizing) the teaching-learning process. The science team at Monona Grove High School is just on the threshold of developing this type of facility. There is a great deal to do and much to be learned in this area in the years ahead. The physical equipment and materials required to facilitate the implementation of the resource center philosophy are, at this writing, in the process of being ordered. The format

for several dozen programs has already been established but a great deal of time will be required to bring these programs to a state of readiness. The development of the wide range of programs needed to personalize learning opportunities for young people will be a continuing task. This phase of the program development along with ongoing curriculum revision will necessitate the continuance of teacher workshops in the future.

Team teaching provides the most effective means of developing and implementing a unified science program. The team approach, if it is a cooperative effort, creates an atmosphere in which the team members constantly interact to improve the quality of teaching. As a result each team member becomes a better teacher than he could be in a self-contained classroom.

The daily period of team evaluation and planning is the ongoing source of the program's strength. The thoroughness with which the team evaluates and plans each day's experience determines the overall effectiveness of the program.

There are two areas of concern associated with unified science which, at this time, are outside the realm of any one particular group developing a unified program.

1) College accreditation of high school courses in unified science - a communication problem with college accrediting personnel, and

2) Teacher training programs which, at the philosophical level, consider the unity which is inherent in science and, at the practical level, the very complex art of team teaching.

The development of a common organizational structure and curriculum for all unified science programs is not a problem. Perhaps the greatest virtue of the unified approach is that many approaches are possible. To develop a program one must take a panoramic view of the broad spectrum of scientific knowledge, identify those ideas which are the basis for understanding natural phenomena, organize these ideas through some sort of conceptual framework, and proceed to structure a program which is unique in terms of the particular needs of a school, its students, and the personality and talents of its teachers. This is the genius of the unified approach to science education.

APPENDIX

1. Sample test (Science IA Modified)
   The Universe and Man

2. Drawing of Original Facilities

3. Drawing of Present Facilities

Hour Exam THE UNIVERSE

Part I (total points 2.0) Select one answer for each of the following questions.

____ 1. A light year is:

1. a measure of the velocity of light.
2. equal to 186,000 mi/sec x 93,000,000 miles.
3. a measure of the time it takes light to reach us from a distant star.
4. 6×10^9 miles per year.
5. unit of distance.

____ 2. Which one of the following is not related to the process of measuring distance in space by the method of parallax?

1. length of the base line
2. two observers
3. two separate measurements on the same object at different times.
4. zenith point
5. accurate angular measurement

____ 3. Proxima Centuri is the name of the star closest to the earth. The time required for light from this star to reach the earth would be approximately:

1. 8.3 LY
2. 3.4 LY
3. 2.4 LY
4. 1.2 LY
5. 4.3 years

____ 4. Which one of the following factors is not relative to the process of measuring the distance to stars by the brightness method.

1. the period of brightness
2. 4π
3. a measure of the time required for the light to reach the observer
4. the apparent brightness
5. the absolute brightness of a cepheid star

____ 5. The "red-shift" is interpreted by most cosmic scientists as an indication that galaxies within the observable universe are:

1. speeding toward each other
2. suspended in space
3. receding from each other
4. slowly dying

____ 6. Cosmologists accept the expansion of the universe, but do not agree on the manner of expansion. One evolutionary theory proposes that the expansion of the universe is

1. such that the average density of matter per unit volume of space is decreasing.
2. such that the average density of matter per unit volume of space is increasing.
3. such that the average density of matter per unit volume of space remains the same.
4. none of the above.

____ 7. The use of pulsating stars (Cepheids) for the calculation of cosmic distances in space is based on:

1. the fact that they are extremely bright by comparison to

1

other stars around them.
2. the fact that their color changes from blue to red is a direct ratio to their distance from the earth.
3. the fact that there is a relationship between their period of pulsation and their real brightness.
4. most cepheids are close enough to be accurately measured using the parallax method.

____ 8. Which of the following statements is true according to the Cosmological Principle?

1. The earth appears to be the center of the Universe.
2. The sun is the center of the Universe.
3. There is no center to the Universe.
4. The Milky Way appears to be the center of the Universe.

____ 9. Which of the following statements comes closest to describing the size of the Universe as we know it?

1. The Universe is composed of our earth, the sun, the other planets and all other heavenly objects which orbit the sun.
2. Our earth and sun comprise only a tiny fraction of the Universe.
3. The universe is made up of many galaxies of stars, some of which resemble our Milky Way. Some of these galaxies are as far as a billion light years away from the earth.
4. The universe is composed of clusters of galaxies. The distance between these clusters is in the order of billions of light years. The number of these clusters is probably greater than the largest number we could ever imagine.

____10. Which of the following statements is not inferred in the cosmological principle?

1. There is a uniform distribution of clusters of galaxies in space.
2. The universe is infinte; it has no boundaries in space or time.
3. The universe is expanding at the present time.
4. The center of the expansion appears to be everywhere.
5. A galactic observer anywhere in the universe will see galaxies in every direction, all of them receding from him.

____11. Which one of the following statements best defines science as we understand the term now?

1. Science is the sum of all knowledge which has been collected and classified by men since earliest times.
2. Science is the only process by which one can acquire knowledge which is new to the experience of man.
3. Science is a process and knowledge is the product of that process. All the knowledge that a person possesses has been acquired by the process of science.
4. Science is a process of inquiry in which one moves from the area of the unknown into the area of the known.

____12. The age of the Earth determined through methods based on the radioactive decay of elements is:

1. 2.8 billion years
2. 5 billion years
3. 2 million years
4. 10 billion years

2

____13. The Earth's fate depends on the Sun. Based on observed behavior of many different kinds of stars, scientists believe that our sun will eventually end up as

1. a red giant
2. a white dwarf
3. a Nova
4. a dark heavy star mass

____14. While we're at rest on the surface of the earth we are actually a part of a system which is in motion. How many different motions does the earth experience as it moves through space?

1. 3
2. 4
3. 5
4. 6
5. 7

____15. The best explanation for the presence of elements heavier than iron in the earth is

1. through radioactive decay.
2. the original dust cloud must have contained these elements.
3. they are continually being formed in the sun.
4. none of the above

____16. From the point of view of scientists today the most acceptable theory to account for the origin of the solar system is:

1. Double Star Theory
2. Nebular Theory
3. Cosmic Cloud Theory
4. Relativistic Theory

____17. Listed below are four different kinds of attitudes which might be those of students taking science courses. In our discussion of the nature of science and its relationship to people five different goals of science teaching were considered. Which one of the attitudes described below does not agree with your understanding of the reasons why a person should take science?

1. Science deals with many different kinds of interesting facts about the nature of things. Since we are going to live in this world it is essential that we learn as much of this factual knowledge as possible.

2. There are certain fundamental ideas in science which provide the basis for interpreting new experience. The purpose of taking science in high school is to understand these fundamental ideas.

3. Science is a process by which one may acquire knowledge. Although this is not the only way in which we learn it is a very important one. One of the major reasons for taking science in high school is to develop skill in the use of the process of science as a method of inquiry.

4. The reason that all students need to take science courses in high school is to help them to understand something about their environment. One of the main reasons for learning about the nature of our environment is that this helps us to understand ourselves and the ways in which we are dependent upon our environment.

___18. In 1944 certain scientists declared that a certain chemical pesticide, DDT, was "safe" for use by the general public. Now, twenty five years later, traces of DDT can be found within the bodies of every living plant and animal in the world. In some cases the DDT concentration is already at a critical level. This illustrates:

1. that the products of science may be good for certain things but in the long run they turn out bad.
2. that scientists cannot tell if a certain product will be good or bad.
3. that man cannot interfere with one segment of his environment without affecting other changes within that segment of the environment.
4. that DDT has been a very effective insecticide and we no longer have this problem to bother us.

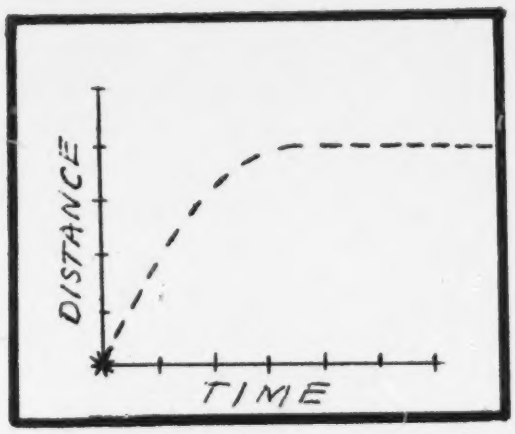
19. Scientists are working cooperatively in an effort to find a cure for cancer. Some scientists like #1 analyze tissue, others like #2 are skilled surgeons, and still others like #3 work exclusively to investigate various hypotheses and theories. Identify which of these scientists would be classified as:

___ a) pure scientists

___ b) practical scientists

Part II. (total points 1.0) The opposite page may be used for calculations.

1



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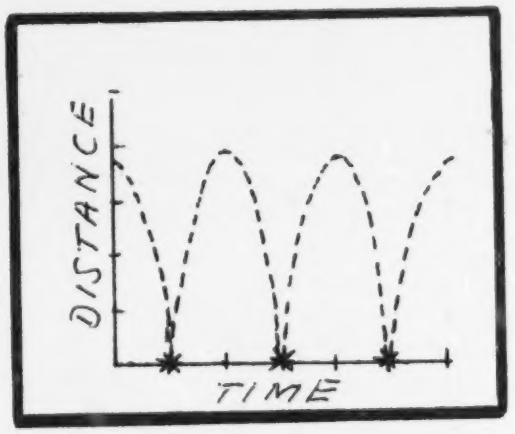
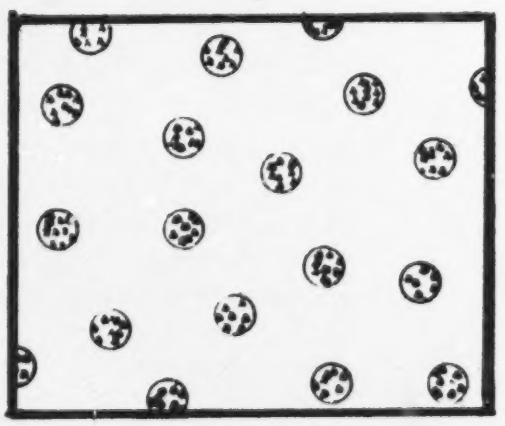


1. The diagrams represent various theories as to the origin and distribution of galaxies in the universe. Answer the following questions by selecting the number or numbers of the diagram(s) which best represents the condition or situation described in the drawing.

3



___1. Not all of the galaxies in the universe are the same age.

___2. The galaxies will reach a maximum speed of recession and then continue to move apart from each other, at that speed forever.

4

___3. Provides the best explanation for the existence of elements heavier than iron.

___4. Evolutionary Theory providing for a universe infinite in space and time.

____2. A train traveling north with a velocity of 60 mi/hour sounds its whistle which has a frequency of 440 vib/sec. You are traveling north, along a highway parallel to the railroad tracks, with a velocity of 30 mi/hour. If the train is still behind your car you will hear:

1. more than 440 vib/sec
2. less than 440 vib/sec
3. about 220 vib/sec
4. about 880 vib/sec

____3. Ursa Major has a recession velocity of 9.3×10^3 miles/sec. If Hubble's constant equals 14 mi/sec for each million LY, the distance to Ursa Major is about:

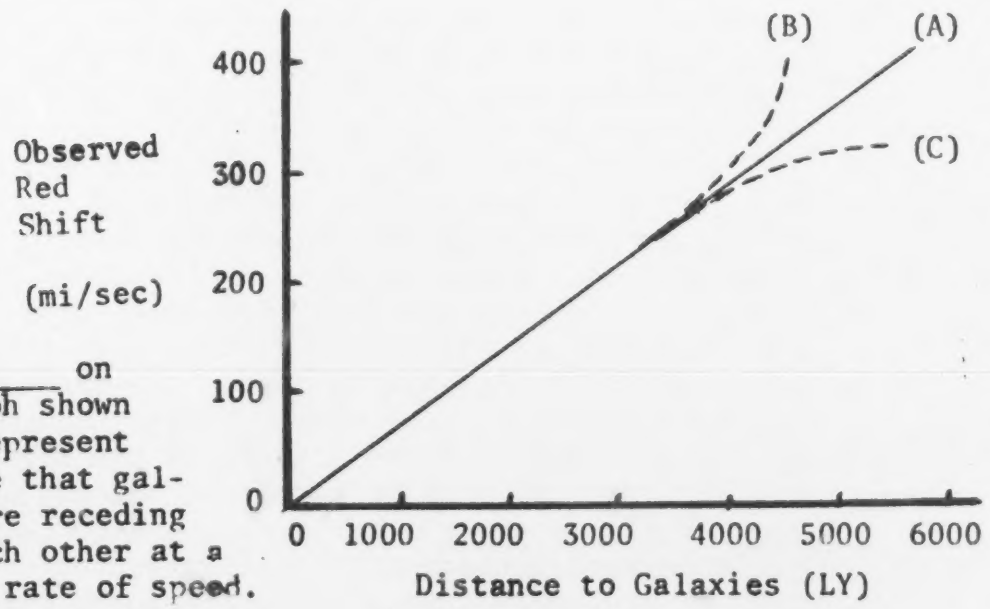
1. 6×10^8 LY
2. 6000 LY
3. 6×10^7 LY
4. 6×10^8 miles
5. 6×10^9 LY

____4. Assume that you were to determine the age of an ore sample by radiogenic techniques. You analyzed a sample of lead ore and found that 12.5% of the atoms were $^{208}_{82}Pb$ which decays from $^{235}_{92}U$. Uranium 235 has a half life of 7.2×10^8 years.
If at the time that the earth was formed this material was 100% uranium 235 the age of this sample would be approximately:

1. 2.2×10^9 years
2. 5.2×10^9 years
3. 3.7×10^{10} years
4. 1.2×10^{10} years
5. 2.9×10^8 years

Part III. (total points 1.0)

1.



___a) Curve _____ on the graph shown would represent evidence that galaxies are receding from each other at a uniform rate of speed.

___b) Curve ____ on the graph would represent evidence that the speed of galaxic recession is slowing down.

5

2. Two students wrote the following statements to summarize their understanding of the nature of the universe. On the basis of what they have said determine whether they should be classified as (E) EVOLUTIONARY or (S) STEADY STATE theorists.

____ a. The universe is composed of an infinite number of galaxies which are moving away from each other. Those galaxies which are most distant from an observer travel with the greatest velocity away from the observer. Although the distance between galaxies is always increasing the density of matter everywhere in space remains the same. According to measurements made in distant galaxies the universe would have to be at least 10 billion years old.

____ b. No one knows how big or how old the universe is. The galaxies which make up the universe are moving away from each other with different rates of speed, and the universe is getting bigger all the time. The galaxies will continue to move apart from each other forever and the universe will never end. Not all of the galaxies in the universe are of the same age. Those galaxies which are older contain stars which are mostly white dwarfs. About 99% of all the matter in the universe is hydrogen which is the simplest type of atom. The stars are made mostly of hydrogen and are formed when huge masses of hydrogen gas begin to whirl and develop forces which compress the gas until the pressures and temperatures become great enough to cause nuclear reactions between hydrogen atoms.

3. A student in our class has suggested that there might be another planet, as yet undetected, orbiting around our sun farther out than Pluto. His reasons for suggesting that this might be the case are as follows. Read each of these ideas carefully. If the idea has a scientific basis for being correct mark the space to the left (S). If you feel the idea expressed is <u>without</u> scientific basis mark it (W).

____ a. Planets are visible only because they reflect light from the sun. It is possible that there could be a small planet so far away from the sun and reflecting such a small amount of light, that even our best light telescopes cannot collect sufficient energy to make it visible.

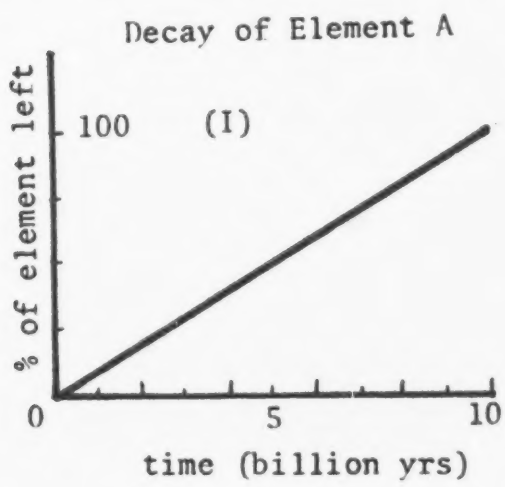
____ b. The orbit of this planet is so big that all during the time that man has been observing the heavens this planet has not yet completed even one half of one revolution around the sun (one planet year). Since during this period of time, the planet has always been on the opposite side of the sun from the earth we have not yet had the opportunity to detect it.

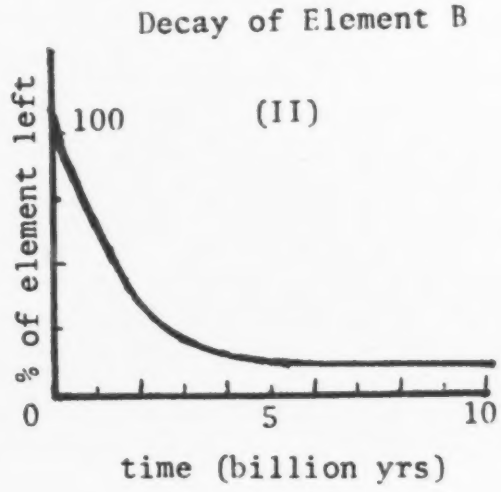
____ c. Although it is possible to detect the presence of planets by use of radio telescopes which "bounce" radio signals generated by the telescope off the surface of the planet this planet has not yet been detected by radio astronomers because they have no idea of the direction they would have to point their antenna in order to make contact with the surface of the planet.

____ d. Even if the antenna of a radio telescope would be, <u>by chance</u>, pointed in the right direction for a "radio" wave leaving the antenna to strike the surface of this planet it would still be

unnoticed because present radio telescopes cannot send signals far enough into space to reach the surface of this planet.

4.





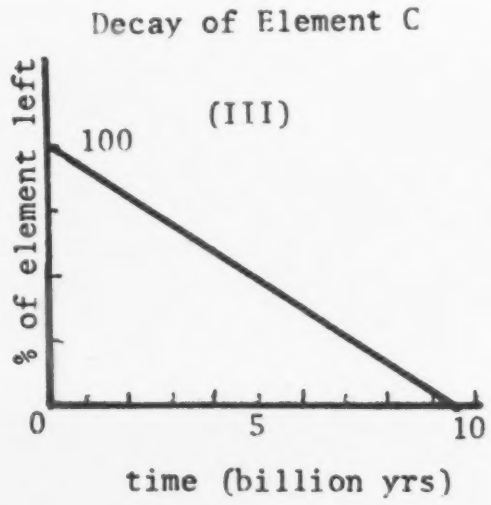
Refer to graphs I - III shown to answer the following:

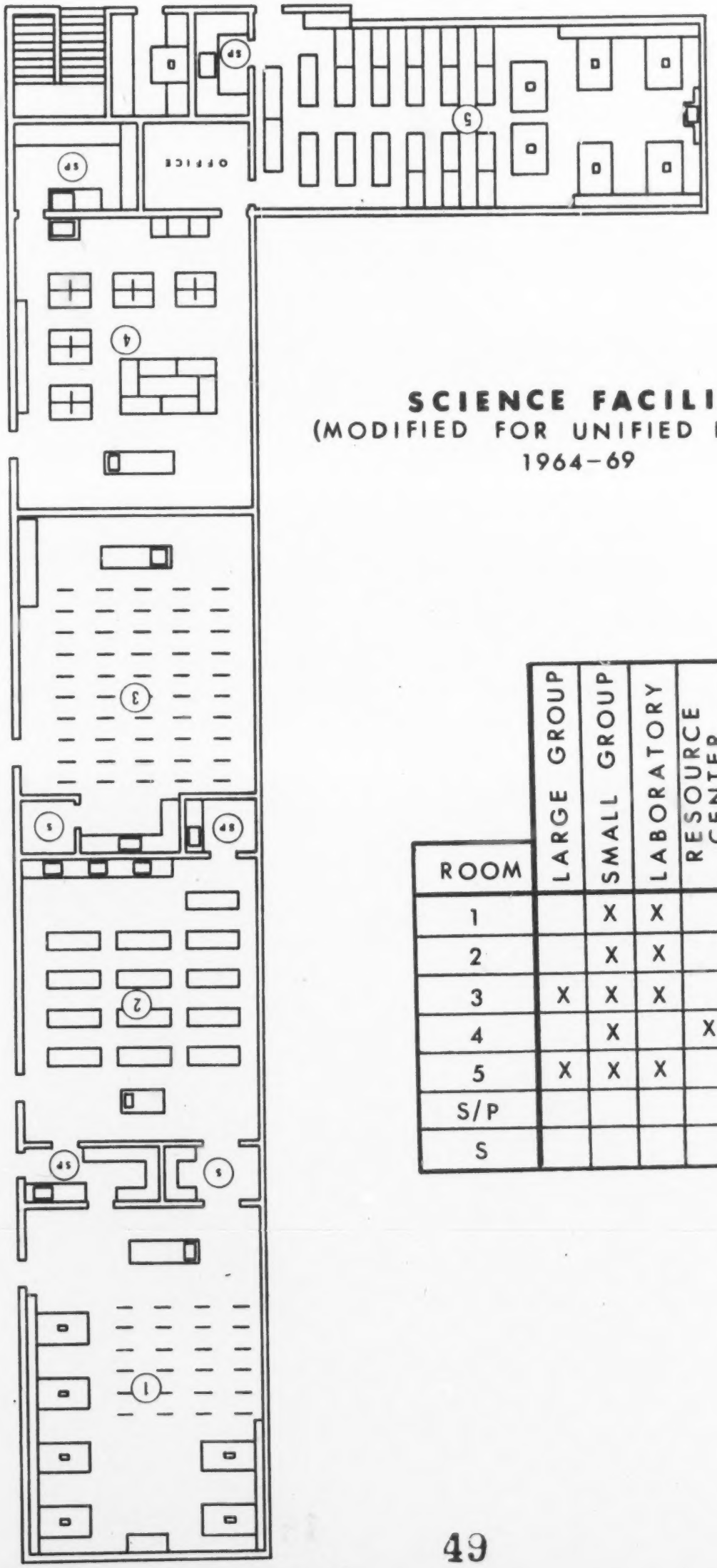
____a. Which graph contains data which would give the present age of the earth?

____b. Which graph represents the element whose half-life is close to 1 billion years?

____c. How long would it be before element C has completely decayed?

____d. How long before element B would decay completely?

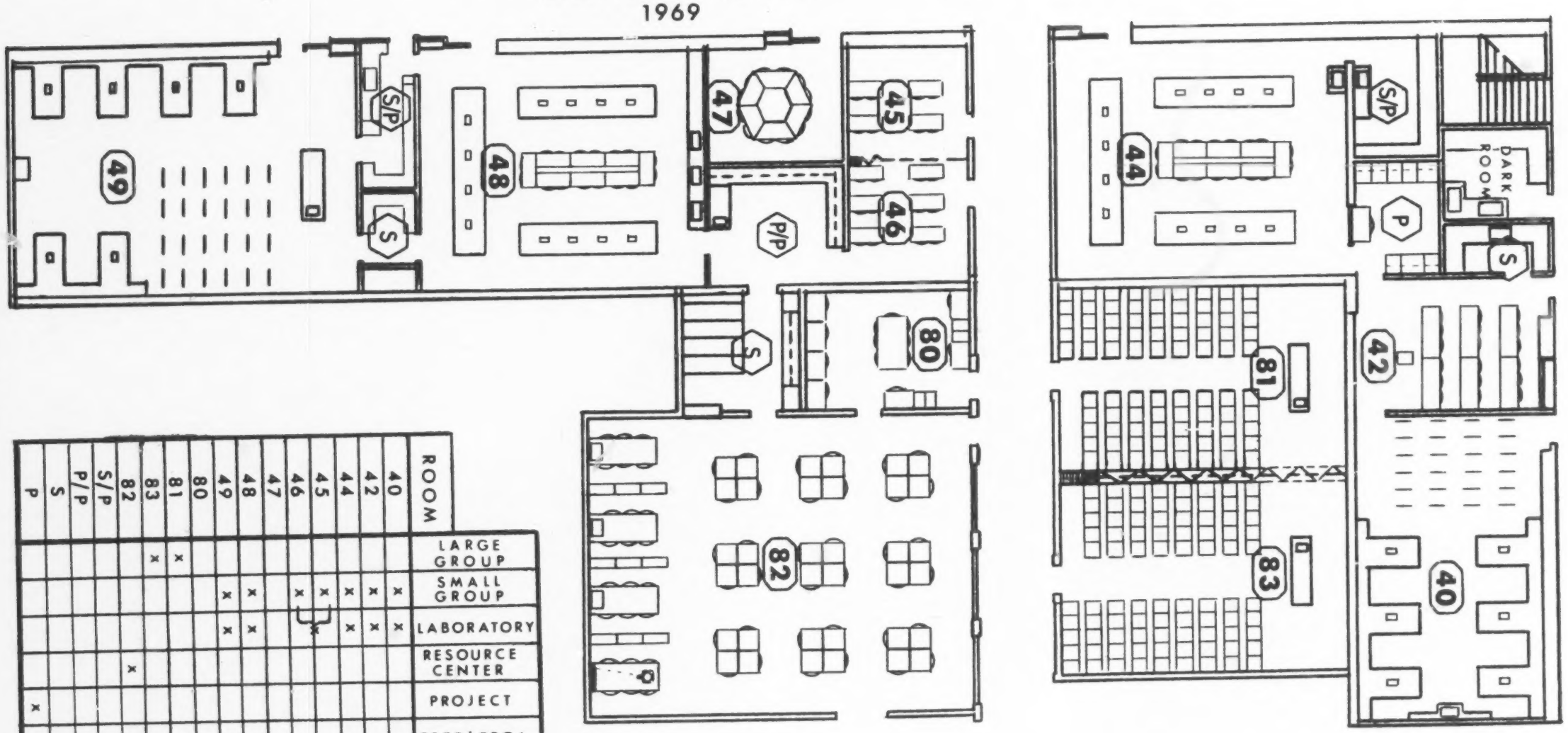




SCIENCE FACILITIES
(MODIFIED FOR UNIFIED PROGRAM)
1964–69

ROOM	LARGE GROUP	SMALL GROUP	LABORATORY	RESOURCE CENTER	STORAGE	STORAGE / PREP
1		X	X			
2		X	X			
3	X	X	X			
4		X		X		
5	X	X	X			
S/P						X
S					X	

SCIENCE FACILITIES
(REMODELED TO ACCOMMODATE)
UNIFIED PROGRAM
1969



ROOM	LARGE GROUP	SMALL GROUP	LABORATORY	RESOURCE CENTER	PROJECT	PREP/ PROJ	STORAGE – PREP	STORAGE	OFFICE
40									
42									
44									
45									
46									
47									
48									
49									
80									
81									
83									
82									
S/P									
P/P									
S									
P									